# 60N04

## N-channel Enhancement Mode Power MOSFET

| | |
|---|---|
| $V_{DSS}$ | 40 V |
| $I_D$ | 60 A |
| $R_{DS(ON)}$ | 5.5 mΩ |

## Features

40V, 60A

$R_{DS(ON)}$ < 7.5mΩ @ $V_{GS}$ = 10V

$R_{DS(ON)}$ < 13mΩ @ $V_{GS}$ = 4.5V

Advanced Trench Technology

Excellent $R_{DS(ON)}$ and Low Gate Charge

Lead Free

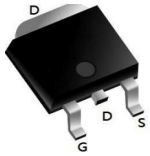
## Applications

Load Switch

PWM Application

Power Management

**TO-252**



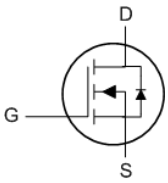

GK XXX
60N04

LOGO GK XXX CODE

60 N 04

ID VDSS

**Equivalent Circuit**




## MAXIMUM RATINGS AND ELECTRICAL CHARACTERISTICS

**Absolute Maximum Ratings** (@ $T_C$ = 25°C unless otherwise specified)

| Symbol | Parameter | | Value | Units |
|---|---|---|---|---|
| $V_{DS}$ | Drain-to-Source Voltage | | 40 | V |
| $V_{GS}$ | Gate-to-Source Voltage | | ±20 | V |
| $I_D$ | Continuous Drain Current | $T_C$ = 25°C | 60 | A |
| | | $T_C$ = 100°C | 38 | |
| $I_{DM}$ | Pulsed Drain Current (1) | | 240 | A |
| $E_{AS}$ | Single Pulsed Avalanche Energy (2) | | 100 | mJ |
| $P_D$ | Power Dissipation | $T_C$ = 25°C | 114 | W |
| $R_{\theta JA}$ | Thermal Resistance, Junction to Ambient (3) | | 37 | °C/W |
| $R_{\theta JC}$ | Thermal Resistance, Junction to Case | | 1.1 | |
| $T_J$, $T_{STG}$ | Junction & Storage Temperature Range | | -55 to 150 | °C |

## Electrical Characteristics ($T_J$=25℃unless otherwise noted)

| Symbol | Parameter | Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| **Off Characteristics** | | | | | | |
| $V_{(BR)DSS}$ | Drain-Source Breakdown Voltage | $I_D$ = 250μA, $V_{GS}$ = 0V | 40 | - | - | V |
| $I_{DSS}$ | Zero Gate Voltage Drain Current | $V_{DS}$ = 40V, $V_{GS}$ = 0V | - | - | 1.0 | μA |
| $I_{GSS}$ | Gate-Body Leakage Current | $V_{DS}$ = 0V, $V_{GS}$ = ±20V | - | - | ±100 | nA |
| **On Characteristics** | | | | | | |
| $V_{GS(th)}$ | Gate Threshold Voltage | $V_{DS}$ = $V_{GS}$, $I_D$ = 250μA | 1.0 | 1.7 | 2.5 | V |
| $R_{DS(ON)}$ | Static Drain-Source ON-Resistance(4) | $V_{GS}$ = 10V, $I_D$ = 30A | - | 5.5 | 7.5 | mΩ |
| | | $V_{GS}$ = 4.5V, $I_D$ = 20A | - | 9.0 | 13 | mΩ |
| **Dynamic Characteristics** | | | | | | |
| $C_{iss}$ | Input Capacitance | $V_{GS}$ = 0V, $V_{DS}$ = 20V, f = 1MHz | - | 2443 | - | pF |
| $C_{oss}$ | Output Capacitance | | - | 167 | - | pF |
| $C_{rss}$ | Reverse Transfer Capacitance | | - | 138 | - | pF |
| $Q_g$ | Total Gate Charge | $V_{GS}$ = 0 to 10V $V_{DS}$ = 20V, $I_D$ = 20A | - | 48 | - | nC |
| $Q_{gs}$ | Gate Source Charge | | - | 10 | - | nC |
| $Q_{gd}$ | Gate Drain("Miller") Charge | | - | 10 | - | nC |
| | | | | | | |
| **Switching Characteristics** | | | | | | |
| $t_{d(on)}$ | Turn-On DelayTime | $V_{GS}$ = 10V, $V_{DD}$ = 20V $I_D$= 20A, $R_{GEN}$ = 3Ω | - | 10 | - | ns |
| $t_r$ | Turn-On Rise Time | | - | 28 | - | ns |
| $t_{d(off)}$ | Turn-Off DelayTime | | - | 40 | - | ns |
| $t_f$ | Turn-Off Fall Time | | - | 7 | - | ns |
| **Drain-Source Diode Characteristics and Max Ratings** | | | | | | |
| $I_S$ | Maximum Continuous Drain to Source Diode Forward Current | | - | - | 60 | A |
| $I_{SM}$ | Maximum Pulsed Drain to Source Diode Forward Current | | - | - | 240 | A |
| $V_{SD}$ | Drain to Source Diode Forward Voltage | $V_{GS}$ = 0V, $I_S$ = 30A | - | - | 1.2 | V |
| trr | Body Diode Reverse Recovery Time | $I_F$ = 20A, di/dt = 100A/us | - | 11 | - | ns |
| Qrr | Body Diode Reverse Recovery Charge | | - | 5 | - | nC |

Notes:
1. Repetitive Rating: Pulse Width Limited by Maximum Junction Temperature.
2. $E_{AS}$ condition: Starting $T_J$=25C, $V_{DD}$=20V, $V_G$=10V, $R_G$=25ohm, L=0.5mH, $I_{AS}$=20A
3. $R_{\theta JA}$ is measured with the device mounted on a 1inch$^2$ pad of 2oz copper FR4 PCB
4. Pulse Test: Pulse Width≤300μs, Duty Cycle≤0.5%.

## RATING AND CHARACTERISTIC CURVES

Figure 1: Output Characteristics

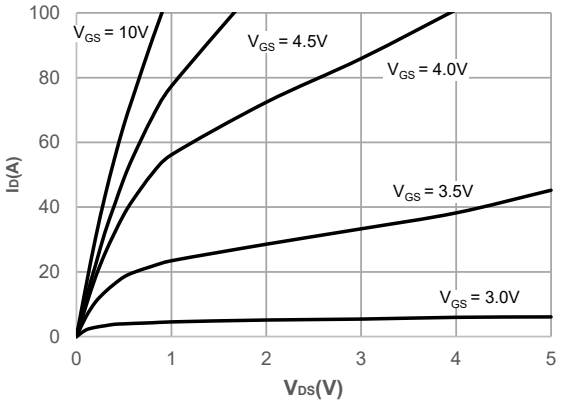



Figure 2: Typical Transfer Characteristics

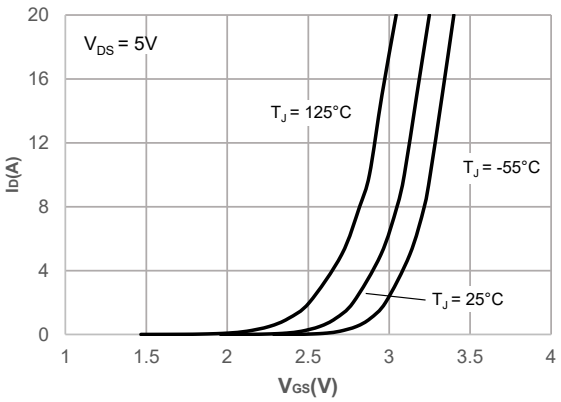



Figure 3: On-resistance vs. Drain Current

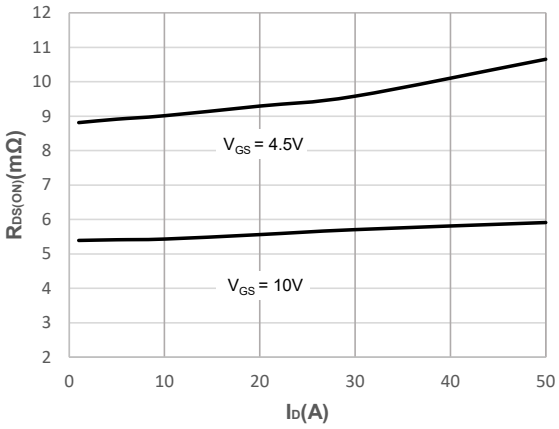



Figure 4: Body Diode Characteristics

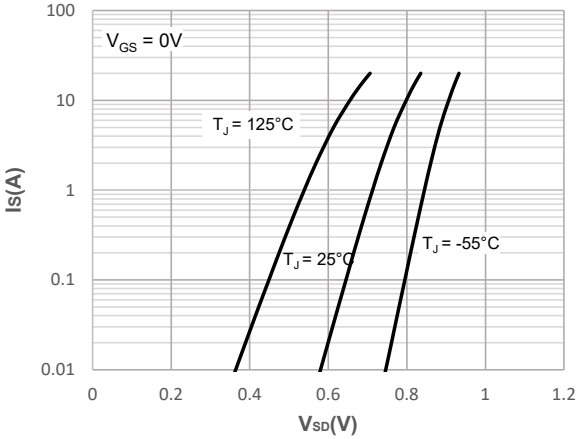



Figure 5: Gate Charge Characteristics

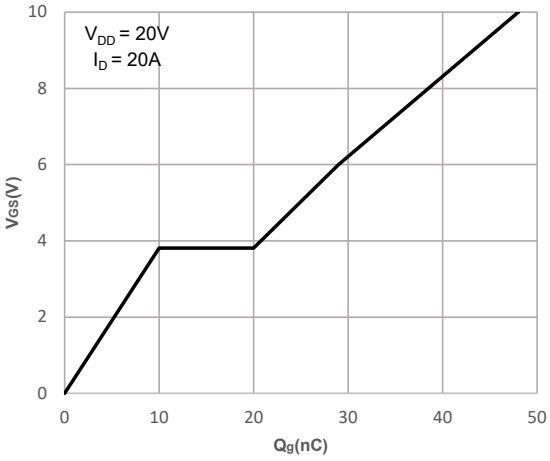
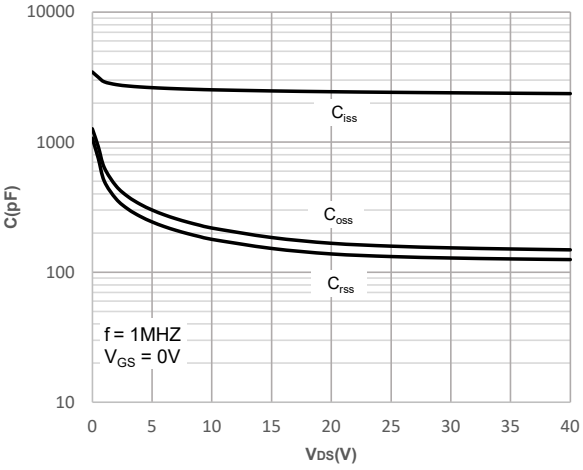



Figure 6: Capacitance Characteristics



## RATING AND CHARACTERISTIC CURVES

Figure 7: Normalized Breakdown voltage vs. Junction Temperature

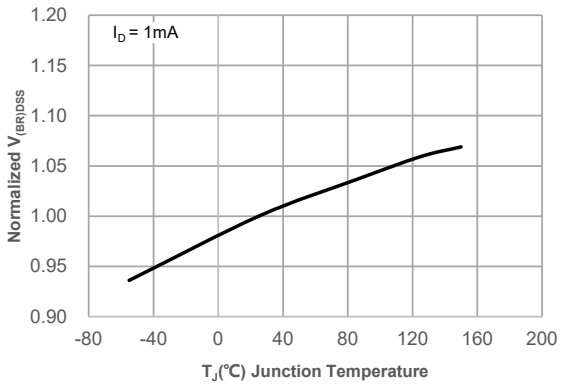



Figure 8: Normalized on Resistance vs. Junction Temperature

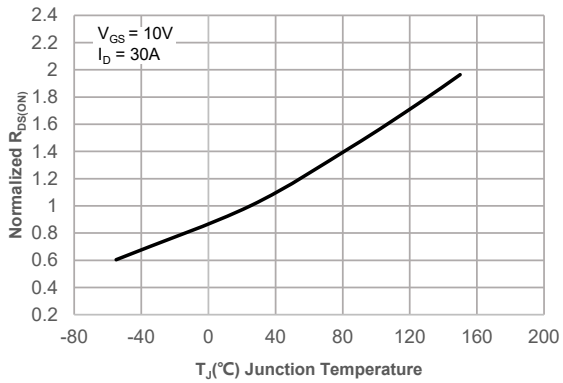



Figure 9: Maximum Safe Operating Area

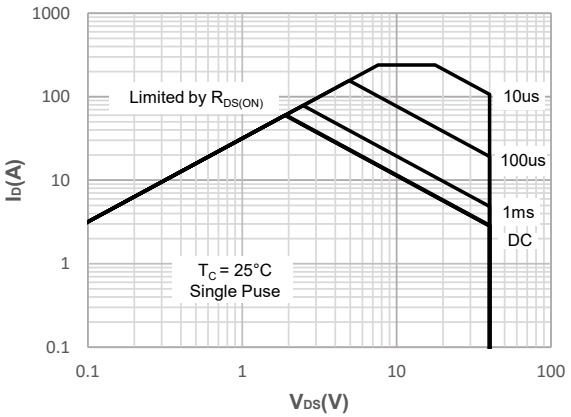



Figure 10: Maximum Continuous Drian Current vs. Case Temperature

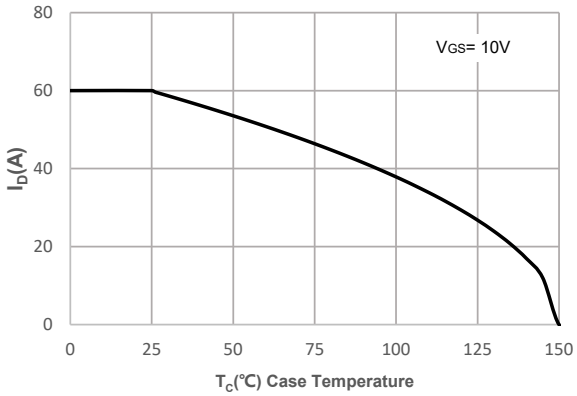



Figure 11: Normalized Maximum Transient Thermal Impedance

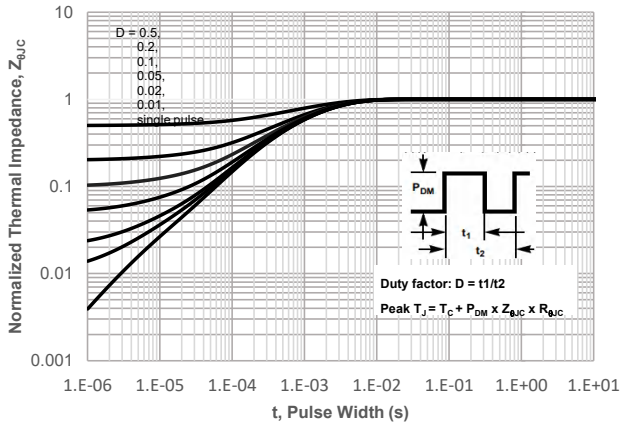
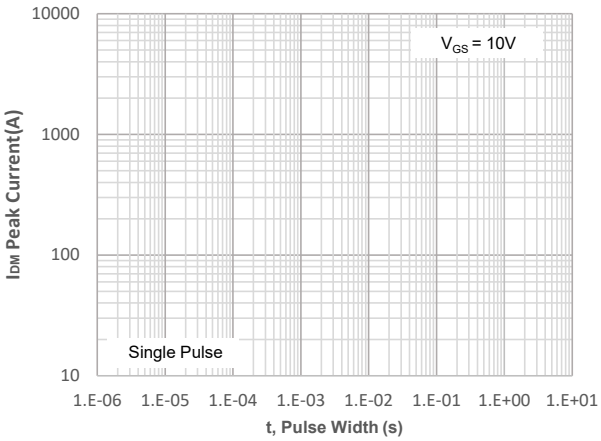



Figure 12: Peak Current Capacity



# Test Circuit

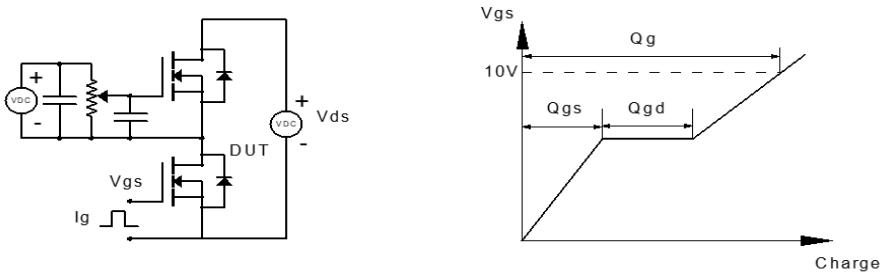



**Figure 1: Gate Charge Test Circuit & Waveform**

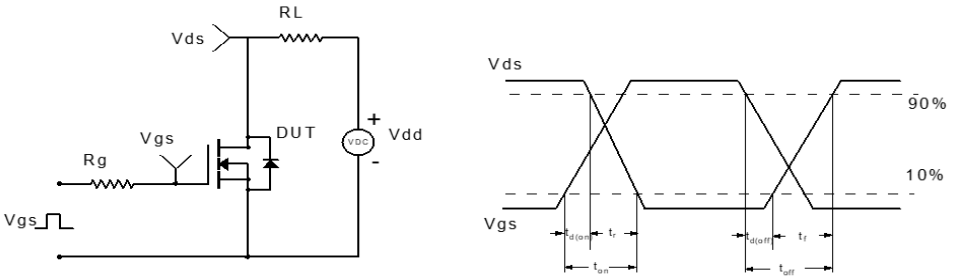



**Figure 2: Resistive Switching Test Circuit & Waveform**

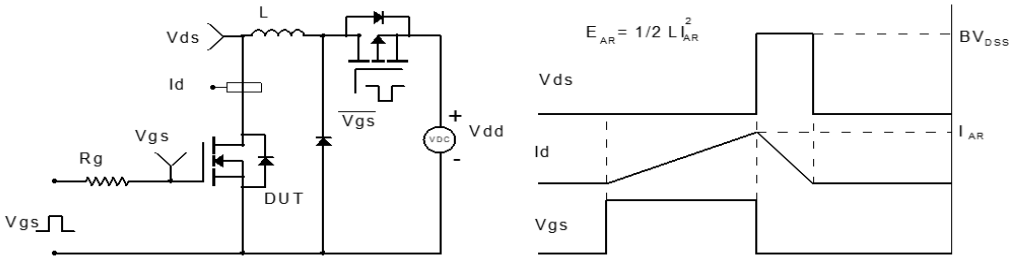



**Figure 3: Unclamped Inductive Switching Test Circuit& Waveform**

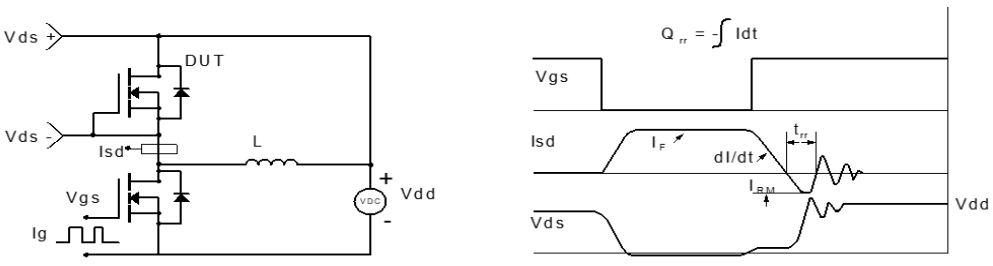
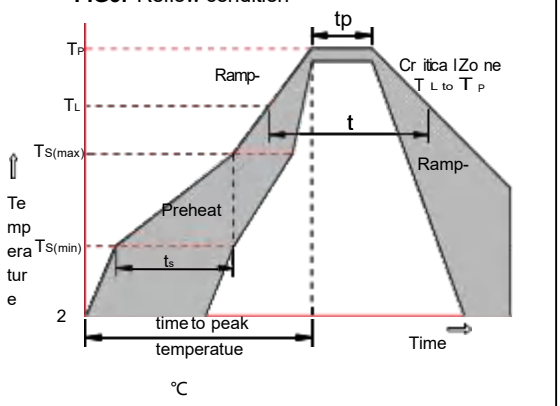



**Figure 4: Diode Recovery Test Circuit & Waveform**

## Soldering parameters

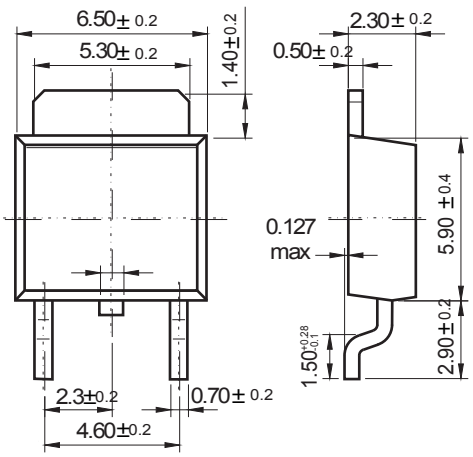
| Reflow Condition | | Pb-Free assembly (see as bellow) |
|---|---|---|
| Pre Heat | -Temperature Min ($T_{s(min)}$) | +150℃ |
| | -Temperature Max($T_{s(max)}$) | +200℃ |
| | -Time (Min to Max) (ts) | 60-180 secs. |
| Average ramp up rate (Liquid us Temp ($T_L$) to peak) | | 3℃/sec. Max |
| $T_{s(max)}$ to $T_L$ - Ramp-up Rate | | 3℃/sec. Max |
| Reflow | -Temperature($T_L$)(Liquid us) | +217℃ |
| | -Temperature($t_L$) | 60-150 secs. |
| Peak Temp ($T_p$) | | +260(+0/-5)℃ |
| Time within 5℃ of actual Peak Temp ($t_p$) | | 30 secs. Max |
| Ramp-down Rate | | 6℃/sec. Max |
| Time 25℃ to Peak Temp ($T_P$) | | 8 min. Max |
| Do not exceed | | +260℃ |

**FIG5:** Reflow condition

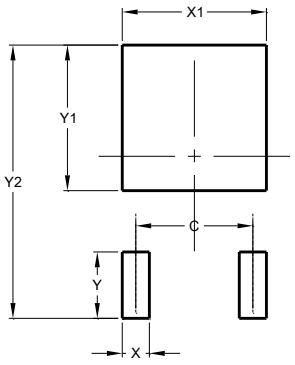



## Package Dimensions & Suggested Pad Layout

TO-252



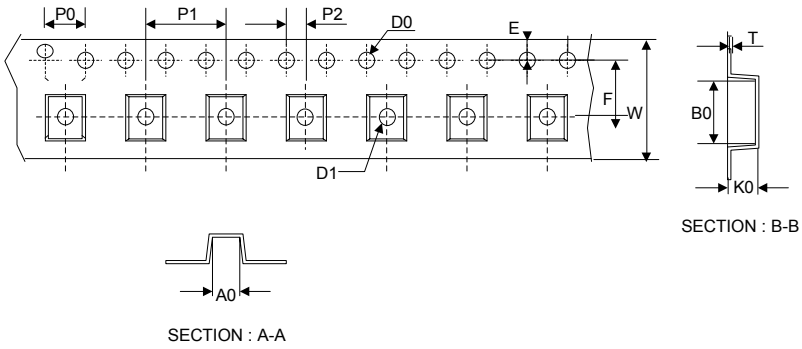

Dimensions in inches and (millimeters)



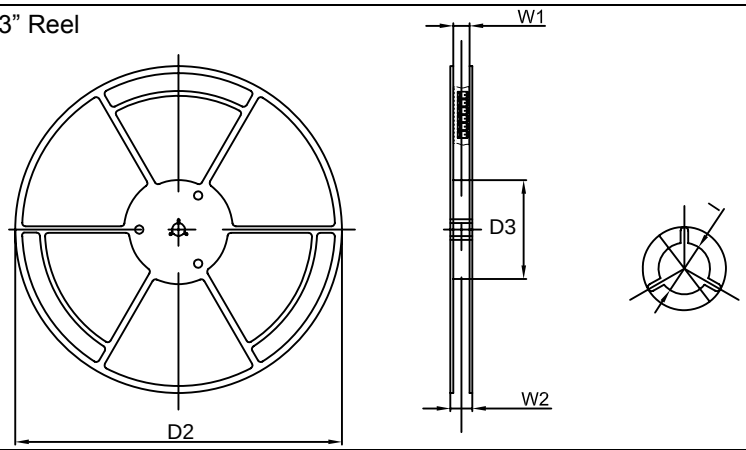

| Dimensions | Value (in mm) |
|---|---|
| C | 4.55 |
| X | 1.50 |
| X1 | 5.80 |
| Y | 2.70 |
| Y1 | 6.00 |
| Y2 | 10.90 |

## Tape & rell specification

Tape




13” Reel




| Symbol | Dimension (mm) |
|---|---|
| P0 | 4.00±0.20 |
| P1 | 8.00±0.20 |
| P2 | 2.00±0.20 |
| D0 | 1.55±0.15 |
| D1 | 1.55±0.20 |
| E | 1.75±0.20 |
| F | 7.50±0.20 |
| W | 16.00±0.20 |
| A0 | 7.10±0.20 |
| B0 | 10.50±0.20 |
| K0 | 2.70±0.20 |
| T | 0.30±0.10 |
| D2 | 330.0±5.0 |
| D3 | 100.0±4.0 |
| W1 | 20.0±5.0 |
| W2 | 25.0±5.0 |
| I | 13.0±2.0 |

Quantity: 2500PCS

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